Risk factors of unintentional injury among children in New Zealand: a systematic review

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Abstract

Objective: To identify contemporary studies investigating multifaceted and inter-linked contributory frameworks for unintentional injuries among children in New Zealand.

Methods: A literature review was performed in seven databases. Studies published in English up to February 2020 reporting risk factors for child injury in New Zealand were included. Eligible study designs included: cohort, case-control and case-crossover studies. The quality of studies was assessed using the GATE frame tool. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) reporting guidelines were followed.

Results: Thirteen studies fulfilled the inclusion criteria, dating from 1977 to 2008. The factors associated with child injury (0 to 14 years) included socioeconomic disadvantage, number of children, younger maternal age and sole parents. Vehicle speed and traffic volume were associated with an increased risk of driveway-related pedestrian injury.

Conclusion: The review findings have reinforced the need for cross-agency action to address the social determinants of child injury.

Implications for public health: Contemporary longitudinal studies are needed to assist in understanding how the interactions between children, family and their wider societal context affect their risk of experiencing injury over time.

Key words: unintentional, injury, childhood, systematic review

Unintentional injuries among children are a major public health concern globally, accounting for up to 90% of all injuries.[1] Road crashes, drowning, burns, falls and poisoning are the most common causes of death and disability among children <19 years of age.[1] In New Zealand, unintentional injuries are responsible for 29% of all deaths among children aged one to 14 years, claiming the lives of 35 children on average annually (2011–2015 data).[2] Unintentional injuries are also the leading reason for emergency department (ED) presentations and hospital admissions among children in New Zealand.[3] Not only do unintentional injuries claim lives, but they can also result in temporary or permanent disability, costly medical attention and – in some cases – long-term care. These serious outcomes of unintentional injuries may influence health and education and have social and economic impacts on not only the child's family but also the economy of New Zealand. In 2008, the social and economic costs per child injury fatality were estimated to be $8.05 million and $778.8 million in total, respectively.[4] The incidence and type of unintentional fatal and nonfatal childhood injuries in New Zealand varies by age group, sociodemographic characteristics and economic and cultural background.[3]

Compared with other high-income countries, New Zealand fares poorly. In 2009, New Zealand had child and adolescent injuries mortality rates that were higher than the Organisation for Economic Co-operation and Development (OECD) average.[5] This may in part be due to a gap in injury prevention policy development and the implementation of existing evidence-based safety measures.[6] It has been estimated that, if implemented, these measures have the potential to prevent up to 90% of fatal and non-fatal injuries among children in New Zealand.[7]

Risks factors for unintentional injuries among children are multifactorial[8] and are commonly broadly categorised as child/individual characteristics (child age, gender, psychological and behavioural factors); family or household level characteristics (socioeconomic status, maternal age, employment, etc) and environmental characteristics (traffic volume, neighbourhood type, deprivation index).[9] These domains of risk factors should simultaneously be considered, as multiple risk factors might together create an environment that impacts on child injury risk rather than focusing on isolated independent risk factors.[10] Theoretical frameworks such as the life-course approach of injury prevention[11] lend themselves to examining a series of interactions among biological, behavioural and psychosocial processes and exposures over time that may contribute to childhood injuries and facilitate understanding how multiple risk factors can serve as mediators, moderators or both.[12]

In order to effectively develop, implement and evaluate successful child injury prevention programs for New Zealand, it is important to understand their multifactorial causes.[13] There are contextual factors unique to New Zealand related to te Tiriti o Waitangi (the Treaty of Waitangi) that are likely to

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play a role in the incidence and outcomes of child injury in New Zealand. Therefore, this systematic review of the published literature aimed to identify contemporary studies that have investigated multifaceted and inter-linked contributory frameworks for unintentional childhood (0 to 14 years) injuries in New Zealand.

Methods

Selection criteria

The studies considered for inclusion in this review were those where the population of interest was children aged 0 to 14 years residing in New Zealand; the study designs were cohort, case-control or case-crossover study designs; and the outcomes of interest included parental/caregiver reported injuries, injuries resulting in medical attention being sought or injuries resulting in death. Studies were excluded if they investigated a specific kind of injury type such as fractures or head injury, were not published in English or if the full-text version was not available.

Information sources and search strategy

A search strategy with broad criteria was predefined to select articles relevant to the study inclusion criteria. The search terms used included: Child* OR Paediatric* OR Adolescent* OR Infant* OR Young AND "New Zealand" OR New Zealand [MeSH] AND "Risk" OR "Risk Factors" OR "Risk Assessment" OR "Probability" OR "Causality" OR "Precipitating Factors" OR "Protective Factors" AND "Wounds and Injuries" OR "Burns" OR "Drowning" OR "Accidental Falls" OR "Poisons" OR "Accidents, Traffic" OR "traffic injury". Type of text (full texts) and language (English) filters were applied to the search.

The electronic databases searched for this review included: PubMed, Cumulative Index of Nursing and Allied Health Literature (CINAHL), MEDLINE (Ovid), Scopus, Excerpta Medica dataBASE (EMBASE), PsycINFO, Cochrane Library, Google Scholar and SafetyLit. A manual search of the reference lists of relevant or related articles was also conducted. Potential studies were initially identified through title screening; abstracts of potentially relevant studies were then reviewed, followed by a review of the full text of potentially eligible studies and duplicates being removed. The methods and results of this review have been presented following the PRISMA guidelines.[14]

Data synthesis and extraction of data items

The information from the included studies was qualitatively summarised and tabulated based on the characteristics of the study population, study design, the type of injury, statistical analysis approach and outcomes (Table 1). The risk factors were classified into three domains: child/individual characteristics; family or household level characteristics; and environmental characteristics. Where available, relative risks (RR), odds ratios (OR) and adjusted ORs (aOR) are reported along with 95% confidence intervals (CIs). In studies where the effect estimates were not reported but the significance level was, the latter was used. A meta-analysis of the data from the included studies was not possible due to their heterogeneity.

Quality assessment

The quality of included studies was critically appraised using the GATE frame developed by Jackson et al.[15] The quality appraisal is based on evaluation criteria abbreviated as RAMBOMAN, where R = recruitment, A = allocation, M = maintenance/completeness of the allocated group, B = blinding, O = objective M = Measurements, and AN = analytical errors.

Results

The initial search identified 579 records; following removal of duplicates, the titles of 406 articles were reviewed, resulting in a further 302 being excluded (Figure 1). Of the 104 abstracts that were screened, 37 articles were excluded, and 67 full texts identified were assessed for eligibility. Following a review of the full-text articles of these studies, 54 were excluded and the remaining 13 studies fulfilled the selection criteria.

Study characteristics

Of the 13 studies included in this review, six were cohort studies,[16-21] six were case-control studies[22-27] and there was one case-crossover study[28] (Supplementary File 1). The earliest study was published in 1977 and the most recent in 2008. Three of the included studies analysed secondary population-level data that involved linking New Zealand census data to mortality data from the New Zealand Health Information Service.[19-21] Blakely et al.[19] and D'Souza et al.[21] used 1991 census night records and linked these to mortality data from 1991 to 1994. Shaw et al.[20] included 1981, 1986, 1991 and 1996 census data and linked this to mortality data followed up for three years up to 1999. The population of interest in these studies was unintentional injury deaths among children aged 0 to 14 years.

The three prospective cohort studies by Langley et al.,[17] Beautrais et al.[16] and Schluter et al.[18] included in the review used data from the Dunedin Multidisciplinary Child Development study,[29] the Christchurch Child Development Study[30] and the Pacific Islands Families cohort study,[31] respectively. The outcome in all of these studies was parental/caregiver reports of non-fatal unintentional injuries that required medical treatment.

In five of the six included case-control studies, the age of participants was 0 to 14 years old.[23-27] In the study by Shaw et al., the children were aged one to five years.[22] Four of the case-control study articles were by Roberts et al.[23-26] The cases in these studies[23-26] include fatal and non-fatal road traffic injuries. The non-fatal injury cases were drawn from a hospital-based registry; whereas the fatal injuries were from Coroner's post-mortem records of children who died in the Auckland region between 1992 and 1994. The controls were matched by age, sex and neighbourhood.

In the case-control study by Chalmers et al., cases (n=110) were non-fatal falls from preschool or school playgrounds that resulted in medical treatment being sought from the Dunedin or Christchurch Hospital EDs from September 1989 to May 1992.[27] The controls (n=190) were children who had fallen from playground equipment and had struck the ground but had not sustained an injury for which medical attention was sought. In the sixth case-control study by Shaw et al., the cases (n=50) were children referred to the Dunedin Hospital ED because of suspected ingestion of poisonous substances within April 13 to July 1973, their controls (n=50) were matched based on age and sex – no information was reported on where the controls were sourced from.[22]

There was one case-crossover study that included 46 children aged between 5 and 15 years from the Auckland region, who were killed or hospitalised by a motor vehicle while walking on foot to or from school between 1992 and 1994.[28]

Table 1: Significant modifiable factors identified from the review.

Modifiable risk factors	Author (year), reference	Risk estimate, 95% Confidence Interval [CI], or p-value)	Injury Mechanism/s	Outcome –source
Socioeconomic status (SES)	Schluter (2006)[18]	Maternal income: RC Income: ≤$ 20000 $20001-$40000 RR =1.59 (1.15, 2.19), >$40000 RR= 1.40 (0.90, 2.16) unknown RR= 1.82 (1.02, 3.23)	All injuries	Non-fatal – Maternal reports
	Blakely (2003)[19]	Income: RC high income ≥$30 000 Medium $10000–$29999 RR= 1.4 (1.0, 2.1) Low < 10,000 RR= 2.3 (1.4, 3.8) NZ Socio-Economic index: RC Class 1, 2, & 3 Classes 4, 5 & 6 RR= 1.5 (1.1, 2.2) No occupation RR= 1.6 (1.1, 2.5) New Zealand Index of Deprivation (NZDep): RC least deprived (1-5 deciles) Most deprived (6-10 deciles) RR= 1.6 (1.2 to 2.1)	All unintentional injuries ICD codes 800–949	Death – New Zealand Census-Mortality data
	Shaw (2005)[20]	Road Traffic Crash (RTC): Income: RC >NZ$33,000 NZ$20,600 to NZ$33,000, RR =0.96 (0.70, 1.32) <NZ$20,600, RR =1.36 (1.01,1.82)	Road traffic crash (RTC) and non-RTC	Death – New Zealand Census-Mortality data
	D'Souza (2008)[21]	RC: Income ≥150% median household income Median to <150%, 80% to median, <80% to 60%, <60% to 40% = NS <40% median aOR =1.83(1.02, 3.28)	All types of unintentional injuries	Death – New Zealand Census-Mortality data
	Roberts(1994)[23]	SES RC: I, II, III IV, V OR= 1.64 (1.04,2.57) VI and others OR =2.82 (1.77, 4.51)	Driveway related pedestrian injury	Hospitalisation – hospital registry Death – coroner's post-mortem record
	Roberts & Norton (1995)[25]	SES RC: I, II, III IV, V aOR=1.46 (0.89, 2.40) VI and others aOR=2.48 (1.49, 4.14)	Driveway related pedestrian injury	Hospitalisation – hospital registry Death – coroner's post-mortem record
Car access	Blakely (2003)[19]	RC ≥ 2 cars 1 car RR= 1.0 (0.8- 1.4) 0 cars RR= 2.2 (1.4- 3.5)	Unintentional injuries ICD codes 800–949	Death – New Zealand Census-Mortality data
	Roberts(1994)[23]	RC: Yes No car OR= 2.35 (1.60, 3.46)	Driveway related pedestrian injury	Hospitalisation – hospital registry Death – coroner's post-mortem record
	Roberts & Norton (1995)[25]	RC: Yes No car aOR= 2.32 (1.55, 3.48)	Driveway related pedestrian injury	Hospitalisation – hospital registry Death – coroner's post-mortem record
	Roberts, Norton, Jackson, Dunn (1995)[26]	RC: Yes No aOR =1.97 (1.06, 3.66)	Driveway related pedestrian injury	Hospitalisation – hospital registry Death – coroner's post-mortem record
Number of children	Roberts (1994)[23]	RC ≤ 2 children 3-4 children OR=1.06(0.76,1.49) 5+ children OR =2.90 (1.68,5.03)	Driveway related pedestrian injury	Hospitalisation – hospital registry Death – coroner's post-mortem record
	Roberts, Norton, Jackson (1995)[24]	RC: ≤ 2 children ≥ 3 children aOR= 3.36 (1.19, 9.50)	Driveway related pedestrian injury	Hospitalisation – hospital registry Death – coroner's post-mortem record
	Roberts &Norton (1995)[25]	RC: 1- 2 children 3-4 children aOR = 1.10 (0.75, 1.59) 5+ children aOR =2.25 (1.20, 4.21)	Driveway related pedestrian injury	Death – coroner's post-mortem record Hospitalisation – hospital registry
Parental separation/ sole parenthood	Beautrais (1981)[16]	RC: No separation (P<0.05) Parental separation	Poisoning or suspected poisoning incidents	Non-fatal – Maternal reported
	Blakely (2003)[19]	RC: 2 parent and other 1 parent RR= 1.3 (1.0, 1.8)	Unintentional injuries ICD codes 800–949	Death – New Zealand Census-Mortality data
	Roberts(1994)[23]	RC: with partner: Sole-parent OR= 1.57 (1.09,2.27)	Driveway related pedestrian injury	Hospitalisation – hospital registry Death – coroner's post-mortem record
	Roberts &Norton (1995)[25]	RC: With partner: Sole aOR =1.78 (1.19, 2.65)	Driveway related pedestrian injury	Hospitalisation – hospital registry Death – coroner's post-mortem record
Maternal age	Beautrais (1981)[16]	RC: (< 25 years) P<0.05 26 to 30 years >3 years p	Poisoning or suspected poisoning incidents	Non-fatal – Maternal reported
	Roberts(1994)[23]	RC: ≥26years ≤25 years OR= 3.80 (2.05,7.08)	Driveway related pedestrian injury	Hospitalisation – hospital registry Death – coroner's post-mortem record

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Table 1 cont.: Significant modifiable factors identified from the review.				
Modifiable risk factors	Author (year), reference	Risk estimate, 95% Confidence Interval [CI], or p-value)	Injury Mechanism/s	Outcome –source
Traffic speed	Roberts, Norton, Jackson, Dunn (1995)[26]	RC: <40 mean km/hr 40-49 aOR =2.28(1.26, 5.69) ≥ 50 aOR= 1.26(0.60, 2.66)	Driveway related pedestrian injury	Hospitalisation – hospital registry Death – coroner's post-mortem record
	Robert, Marshal (1995)[28]	RC: ≤50 km/hr >50km/hr RR = 3.59 (1.54, 8.38)	Driveway related pedestrian injury	Hospitalisation – hospital registry Death – coroner's post-mortem record
Traffic volume	Roberts, Norton, Jackson, Dunn (1995)[26]	RC: <250 of vehicles/hr 250-499 aOR = 6.32 (2.43,16.40) 500-749 aOR =7.28 (3.09, 17.20) ≥ 749 aOR =14.30 (6.98, 29.20)	Driveway related pedestrian injury	Hospitalisation – hospital registry Death – coroner's post-mortem record
	Robert, Marshal (1995)[28]	RC: ≤1000 cars/hr >1000 cars/hr RR = 6.31 (2.12, 18.78)	Driveway related pedestrian injury	Hospitalisation – hospital registry Death – coroner's post-mortem record
Car parked density	Roberts, Norton, Jackson, Dunn (1995)[26]	RC: <5% Car parked 5-9% aOR =1.93(0.79, 4.69) >10% aOR =8.12(3.32, 19.90)	Driveway related pedestrian injury	Hospitalisation – hospital registry Death – coroner's post-mortem record

Exposures measured

Child factors

Two cohort studies[17,18] and four case-control studies[22,24-26] analysed child factors. The risk of unintentional injuries was higher among children aged seven weeks to 12 months (aRR 13.3 95%CI 7.0, 25.3) and 13 months to 24 months (aRR 23.3 95%CI 12.3, 44.1) when compared with infants younger than six weeks of age.[18] Langley et al. reported that male children were at increased risk of unintentional injuries.[17] Two studies also reported Māori children were more likely to sustain driveway-related pedestrian injuries compared to other ethnic groups (ranging from aOR 2.92 95%CI 1.02, 8.35 to aOR 2.25 95%CI 1.43, 3.54).[24,25] A prospective cohort study among Pacific Islands families found that children born from a non-Pacific mother (who were eligible in the study through the Pacific Islands ethnicity of the father) were more likely to experience injuries (aRR 2.42 95%CI 1.62, 3.63) when compared to Samoan children.[18]

Roberts and Norton in their case-control study exploring risk factors for child pedestrian–motor vehicle injuries reported increased risk among those with abnormal vision (aOR 4.25 95%CI 1.68, 10.8).[25] Shaw et al. in their case-control study of risk factors for poisoning found an increased risk (*p*<0.05) associated with children's high exploring ability (Gesell developmental test), lower intelligence (Stanford-Binnet intelligence test), lower level of communication (Silva's subjective behavioural characteristics), girls with abnormal appetite, pica and those with a history of previous poisoning.[22] Beautrais et al. similarly stated children with an increased number of reported behavioural problems are significantly associated (*p*<0.05) with increased poisoning incidents.[16]

Family factors

Most of the studies included in this review identified aspects of family factors as possible associated factors of unintentional childhood injuries.[16,17,26,18-25] One of the most widely reported family factors was household/family socioeconomic status (SES),[17-21,23-26] which was objectively measured using a range of methods including household or family income, education and car access. The significant findings of socioeconomic status and other factors are summarised in Table 1.

D'Souza et al., in their cohort study examining death from all types of unintentional injuries, found that children in lower-income groups (<40% median) were at increased risk of dying from unintentional injuries (aOR 1.83 95%CI 1.02, 3.28).[21] Shaw et al. also reported lower income (<NZ$20,600) was a risk factor for road traffic injury (RTI) related death (aRR=1.36; 95%CI, 1.01, 1.82).[20] Similarly, Roberts et al.[25] (aOR 2.48 95%CI 1.49, 4.14) and Blakely et al.[19] (aRR 2.3 95%CI 1.4, 3.8) reported that children from lower SES households were at increased risk of experiencing an injury resulting in admission to hospital/death; whereas, a study by Schluter et al. reported NZ$20,001–NZ$40,000 as a risk factor compared to lower income (≤NZ$20 000; aRR 1.59 95%CI 1.15, 2.19).[18] Three other studies; however, showed no association between household income and unintentional injury risk of injury among children.[17,24,26]

Four studies reported that children with sole or single parents were more likely to experience a fatal or non-fatal injury.[16,19,23,25] Risk estimates ranged from aRR 1.3 95%CI 1.0, 1.8[19] to aOR 1.78 95%CI 1.19, 2.65.[25] In contrast, two studies found no association between injury risk and parental relationship status.[18,24] The number of children in the family was also explored as a potential risk to unintentional injury in six studies,[17,18,22-25] but it was only significantly associated in two studies.[24,25] Both of these studies found that a child with five or more siblings was at a higher risk when compared to children with one or two siblings (aOR 2.25 95%CI 1.20, 4.21);[25] (aOR 3.36 95%CI 1.19, 9.50).[24] Four studies explored the role of maternal factors in child injury.[16-18,23] Roberts found young maternal age (<25 years) was associated with hospitalisation or death from RTIs (OR 3.80 95%CI 2.05, 7.08).[23] Beautrais et al., in their analysis of the Christchurch Child Development Birth Study, found maternal use of tranquillisers and/or anti-depressants (*p*<0.05) was associated with poisoning.[16] Shaw et al. in their study of maternal-reported poisoning cases, found lower scores (from Parental Attitude Research Instrument) of maternal fear of harming their child (p<0.05) and activity approval of the child by the mother (*p*<0.05) were associated with an increased risk of non-fatal poisoning.[22]

Environmental factors

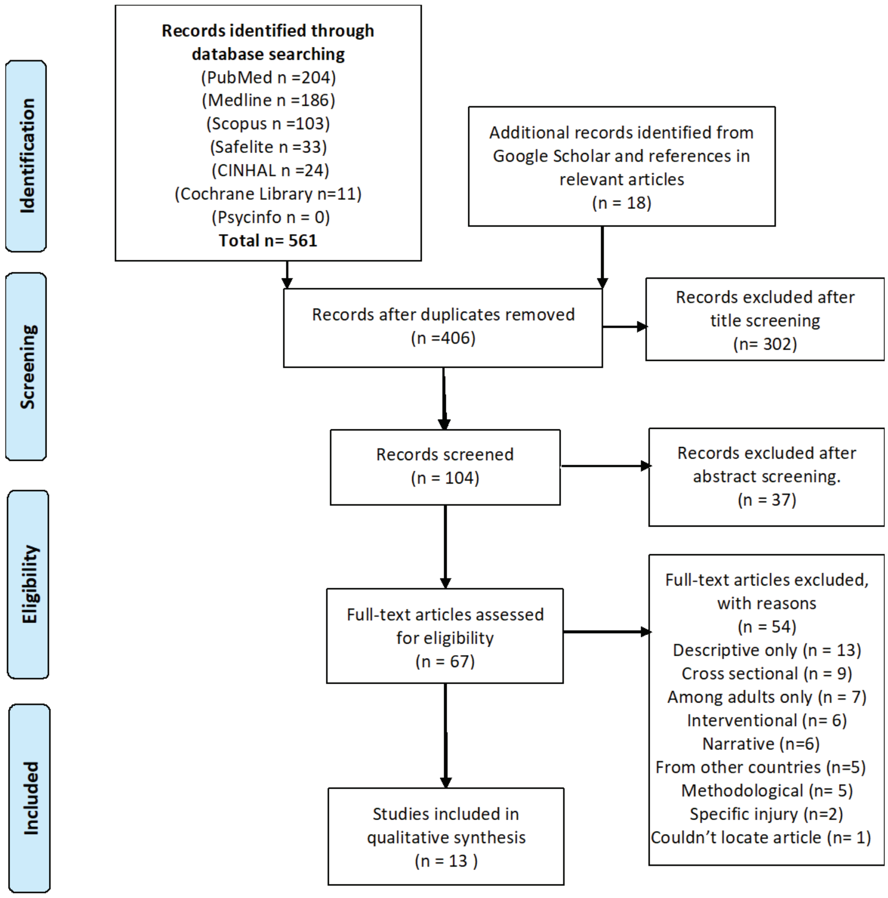
Seven studies included in the review explored the role of environmental factors in unintentional child injury.[19,23-28] The mean speed of a vehicle (40–49 km/hr; aOR=2.28; 95%CI 1.26-5.69) and traffic volume of more than 250–499 vehicles per hour (aOR=4.52; 95%CI 2.04 to 9.98) and 500–749 vehicles per hour (aOR=7.28; 95%CI 3.09-17.20) were associated with increased risk for fatal or non-fatal RTI among children aged younger than 14 years by Roberts et al.[26] In this same study, a high density of curb parking (more than 10% of cars parked) was associated with an increased risk of child pedestrian injury (aOR=8.12; 95%CI 3.32-19.90).[26] Two[25,26] out of three studies examining the relationship between access to cars at home and risk of pedestrian injury reported children with no access to cars at home were more likely to be at risk of experiencing a pedestrian injury. The effect estimates ranged from aOR=1.97; 95%CI 1.06-3.66[25] to aOR=2.32; 95%CI 1.55-3.48.[26]

Blakely et al., in their cohort study exploring the role of neighbourhood deprivation and its relationship to unintentional injury death, found that children from the most deprived areas (Deciles 6–10) of New Zealand were 1.6 (95%CI 1.2-2.1) times more likely to die from unintentional injury when compared to children living in the least deprived (Deciles 1–5) neighbourhoods.[19] Chalmers et al. investigated the risk of childhood injury resulting in seeking medical attention as a result of falls in the school playground.[27] The authors reported that the risks increased where schools failed to comply with the New Zealand playground safety standard (NZS 5828)[32] for safe fall heights (aOR=2.1; 95%CI 1.1 to 4. 0), and when the heights exceeded 1.5 meters (aOR=4.14; 95%CI 2.26 to 7.61).[27]

Discussion

The aim of this review was to identify contemporary studies that have investigated multifaceted and inter-linked contributory frameworks unintentional injuries among children aged less than 15 years in New Zealand. The review identified 13 studies, with the included prospective cohort studies recruited children from as far back as 1977, while the included case-control studies were conducted in the 1990s. The majority of the studies focused on single-level exposures. Given the nested nature of child characteristics, household and wider social and physical environment and the existence of relationships among risk factors and pathways via which the risk is transmitted, a single independent variable might not directly implicate the occurrences of unintentional childhood injuries.[33]

Figure 1: PRISMA Flow Diagram.



Unintentional injuries consist of multiple subsets of injuries referring to any harm or poisoning occurring in the absence of deliberate means or inflicted by inadvertent intent, even if there is evident carelessness.[1,34] This review has explored a variety of unintentional injury outcomes such as maternal or primary caregiver reported poisoning or suspected poisoning incident, maternal reports of all types of non-fatal and/or fatal injuries where medical treatment was sought, and a case study with multiple published articles in relation to hospitalisation and death of driveway-related pedestrian injury (Table 1). Some risk factors might be precisely related to certain types of unintentional injuries among children; however, there is a wide range of demographic, social and broad environmental factors shared among all kinds of unintentional injuries.

The majority of studies in this review adjusted for age and gender.[18-21,24-27] The study by Schluter et al.[18] explored the relationship between age and injury risk in very young children and found that as age increased, so did the risk of injury consistent with some international literature.[35,36] However, the role of age as a risk factor of unintentional injury is confounded by developmental stages among children.[37] For instance, in the first few days of life, infants are most at risk of suffocation and strangulation; in contrast, in the first three years of life, the risk of unintentional poisoning is higher among this age group compared to their younger counterparts.[38,39] The findings of this review have confirmed the relationship between a child's developmental stages and the risk of unintentional injury.[16,17] As was the case in this review, international studies have found that developmental, behavioural and biological characteristics of some children put them at higher risk of unintentional injury.[40,41]

The role of gender was explicitly explored in two prospective cohort studies in this review;[17,18] both of which identified males to be at a higher risk of childhood injury than females. This is consistent with published literature from other countries.[40,41] Similar to international studies,[42,43] other child characteristics such as the child's ability to discover and their intellectual ability, history of injury, and motor development were also identified as risk factors for unintentional childhood injury in the present review.

Several studies in this review reported the association between ethnicity and the risk of unintentional injury. Two out of five studies reported that Māori children were more likely to experience unintentional injury compared to other ethnic groups.[24,25] However, other findings were not consistent.[18,26] Globally, indigenous children were at higher risk of experiencing injury when compared to non-indigenous children.[44] Similarly, in New Zealand, the burden of fatal and non-fatal unintentional injury is disproportionately carried by Māori children compared to their non-Māori counterparts.[3]

Most of the studies (n=9/13) in this review reported the socioeconomic position of the family as a risk factor for unintentional injury. Different indices or scores of SES were used to measure this within the included studies. Four[19-21,25] out of nine studies reported that lower SES was associated with the risk of unintentional injury after adjusting for possible confounding variables with effect estimates ranging from RR=1.36; 95%CI, 1.01 to 1.82[20] to aOR=2.48; 95%CI, 1.49 to 4.14.[25] Similarly, the study by Campbell et al. from the UK Millennium Cohort Study found that children from the lowest income quintile were 1.2 times (95%CI 1.05, 1.37) more likely to be injured compared to those from the highest income quintile.[40] Neighbourhood deprivation was also identified as a risk factor in this review. A cross-sectional study in New Zealand reported that children living in socioeconomically deprived areas have significantly higher injury rates.[45] However, the findings in this review should be interpreted cautiously due to the variability of the SES measures used.

In this review, maternal characteristics were identified as significant risk factors for unintentional injury in children. They included younger mothers in more than one study and the effect of maternal supervision, but the finding of poor maternal mental health was inconsistent. An Australian cohort study by Cameron et al. has found children of younger mothers are at 3.7 times increased risk of recurrent injury.[46] This pattern could be related to a lack of maternal awareness of the injury risks that children encounter as they develop and become more active.[47] Related to this, studies have shown that children growing up in households in which there is a stressed or depressed parent and a socioeconomic disadvantage are more likely to be injured.[38,40]

Consistent with international studies,[48,49] four out of six studies included in this review reported children with single/sole parents were significantly more likely to experience an unintentional injury. Additionally, three out of six studies stated that an increased number of siblings resulted in a substantially higher risk of unintentional injury among children. This was also true in children with multiple siblings[1,50] and/or simply having an older sibling.[51]

Most of the environmental factors identified in this review relate to pedestrian injuries.[25,26,28] Higher driving speeds, high traffic volumes and more roadside parking were associated with increased risk of these injuries, which was concurrent with other published studies.[1,52] Other modifiable environmental risk factors identified in this review were increased risk of fall injury in school playgrounds in school areas where the height and surfacing of the playground equipment did not meet New Zealand safety standards, which was also reported in two other Canadian studies.[53,54]

Strengths and limitations

This review followed a systematic approach to identifying and assessing relevant studies. The methods and results have been presented in line with the PRISMA reporting guidelines.[14] Additionally, this review is based on a wide-ranging search of multiple electronic databases with no publication date restrictions. However, since only published articles and those written in English are included in this review, selection and publication bias may be present. Heterogeneity in the design of the included studies also restricted the ability to pool results.

The quality of the included studies was assessed using the GATE framework.[15] This review included cohort, case-control and case cross-over studies; these study designs offer a higher level of evidence for identifying the relationship between exposures and the risk factors for injury. Studies that collect longitudinal information or have time-related exposure can help to disentangle the temporality of associations and thus have the potential to deliver reliable and robust scientific evidence.[55] The risk of residual cofounding in the reviewed studies was minimised to a degree by the inclusion of multivariate analyses in four of the case-control and four of the cohort studies. However, the issue of residual confounding may persist as there could still be many unmeasured or poorly measured confounders or proxies for these. In addition, five out of six of the included case-control studies employed matching of the cases and controls by age, sex and neighbourhood to control the effects of known potential confounding variables.

Generally, the overall methodology and reporting of outcomes were reasonably unbiased and acceptable. However, there are some methodological concerns. Six out of the 13 included cohort and case-control studies used the New Zealand Census Mortality Study and hospital registry along with the Coroner's post-mortem records, respectively. The advantage of using census data or hospital registers is that it is time and cost-effective, and the data include large sample sizes that draw on extensive data representing the target population concerned and outcome of interest (total hospitalisations and cases of mortalities) in the country or region. However, these secondary data sources are comprised of data gathered for administrative purposes, and as such may not contain all information relevant to the research questions being studied. The primary bias with hospital-based registries of national databases is completeness (whether hospitals submit data on all eligible patients) and accuracy (issue of case ascertainment), which leads to a high level of selection bias.[56] In injury, case ascertainment usually depends on identifying the ICD codes, and these are subject to coding error. As a result, the outcome of interest may be missed or incorrectly identified. In New Zealand, there is a reported 5–18% error rate with ICD injury coding.[57]

The second limitation with using hospital registry or census data is that exposures are usually measured at the time of data collection, which may not necessarily be close to the time of injury. If there is a wide time gap between the reported child injury and the census night, exposures measured at the time of census night might not reflect the actual exposures at the time of injury.

All of the included prospective cohort studies[16-18] and one of the six case-control studies[25] relied on data reported by children's parents/caregivers. Previous research has shown that parents/caregivers are more likely to recall or relate the exposures and injuries when the time interval being asked about is relatively shorter or more recent.[58] Self-reporting can also lead to information bias in which participants usually tend to give a socially acceptable response, especially if the exposure is measured after the incidence of child injury.[59] Three of the studies in this review attempted to minimise this bias by cross-checking the exposures and the hospital registries' outcomes from family doctors and other records.

Conclusion

The studies reviewed have highlighted several important risk factors in socioeconomic disadvantage, increased number of children, younger maternal age and road traffic-related factors. However, most of the studies lacked contemporary methods that comprise the complex and inter-linked contributory nature of childhood injury risk. Future epidemiological studies are required to focus on the relationships between child, family and neighbourhood characteristics and injury from birth to any age of interest. Birth cohort longitudinal designs are well placed to provide this evidence, highlighting the need for contemporary cohort studies such as Growing Up in New Zealand,[60] which contains context-relevant evidence to determine the process of causal pathways that lead to developmental childhood outcomes for children born in the 21st century. It could also assist with timely points for the delivery of effective childhood injury prevention interventions.

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